

A Low Cost Analog and Digital TV (DVB-T) Modulator

News

(Jun 13, 2005) First public release

What is it ?

This is not a hoax ! With a PC running Linux and a recent VGA card, you can emit a real digital TV signal in the [VHF band](#) to your [DVB-T](#) set-top box.

DVB-T emitters are usually very expensive professional devices. Now with a standard PC you can broadcast real DVB-T channels !

Examples to transmit [PAL](#) or [SECAM](#) analog signals directly to your TV are also presented.

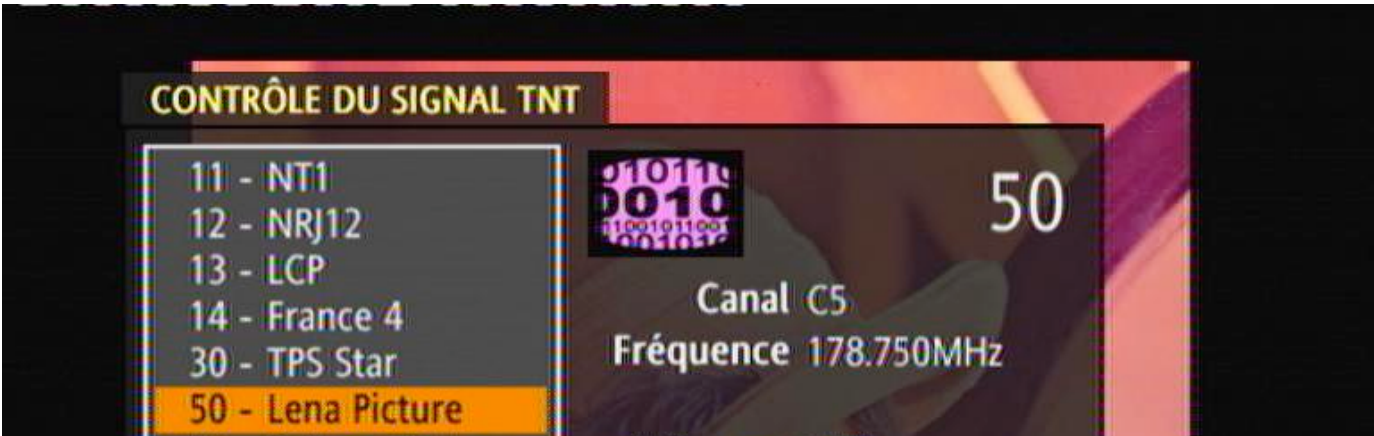
What do you need ?

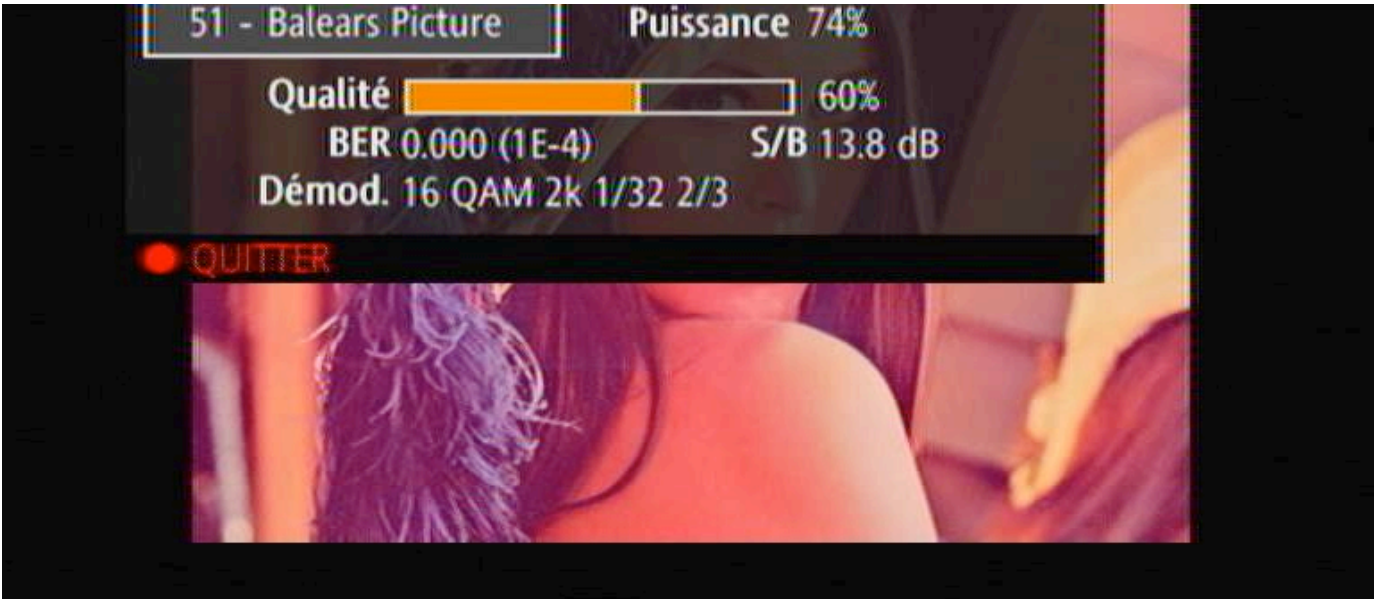
- A good knowledge of X Window and Linux and basic knowledge in electronics.
- A DVB-T set-top box able to receive VHF signals with a bandwidth of 8 MHz (unfortunately most decoders sold in UK only receive UHF signals). You can use French DVB-T receivers which accept VHF and UHF RF signals.
- A PC with a recent VGA card able to display in resolutions up to 4096x2048 with 8 bit per pixel with a pixel clock of *exactly* 76.5 MHz. ATI Radeon 9200SE are reported to work (their PLL can generate every frequency which is a multiple of 2.25 MHz up to 400 MHz). Other VGA cards may work too. If your card cannot generate a 76.5 MHz pixel clock, I can provide alternate images to do some testing.
- A cable connecting the [VGA output](#) to the set-top box RF input. It is possible to use antennas, but since the transmit power is very low, it is better to begin with a cable connection.

15 pin VGA connector		9.5mm RF connector
-----		-----
1 (red signal)	<----->	RF signal (central pin)
6 (red ground)	<----->	GND

Screenshots

Here are some screenshots showing the transmitted pictures. A [Netgem iplayer](#) DVB-T set-top box was used as receiver. The On Screen Display of the set-top box shows the signal parameters and quality. The pictures were grabbed using a PC TV grabber connected to the composite video output of the set-top box.





How to proceed ?

- Add the following configuration at the end of your X Window server configuration file (usually `/etc/X11/XF86Config` or `/etc/X11/Xorg.conf`):

```
#####
#VGA modulator config
Section "Monitor"
    Identifier      "MonitorDAC"
    VendorName      "Monitor Vendor"
    HorizSync       1.0 - 200.0
    VertRefresh     1.0 - 200.0
    Mode "dac1"
    DotClock 76.50
    # PAL/SECAM
    HTimings 4064 4064 4072 4080
    VTimings 748 748 749 750
    EndMode

    Mode "dac2"
    # DVB-T
    DotClock 76.50
    HTimings 3656 3656 3664 3672
    VTimings 1307 1307 1308 1309
    EndMode
EndSection

Section "Screen"
    Identifier      "ScreenDAC"
    Device          "Videocard0"
    Monitor         "MonitorDAC"
    DefaultDepth     8
    SubSection "Display"
        Depth       8
        Modes        "dac2"
    EndSubSection
EndSection
#####
```

This configuration won't be used by default by the X Window server, so you can leave it in your default X Window configuration. `videoCard0` is assumed to be the name of your default video card.

- Launch an X server using this configuration (we assume the display `:0` is your already running X11 display):

```
X :1 -ac -screen ScreenDAC
```

Your monitor will of course not be able to display anything because the timings are far from correct VESA timings. Unless you are using a very old monitor, there is no chance you can destroy it..

Wait a few seconds and switch back to the starting X11 display (in most Linux distributions Ctrl-F7 does it). Then look at the X11 log file to see if everything was OK (usually in `/var/log/XFree86.1.log` or `/var/log/Xorg.1.log`).

- Download the following gray level image: dvbt.pgm.gz and decompress it.

Display it on the `:1` X11 display:

```
display -display :1 -window root dvbt.pgm
```

- Switch to the `:1` display (usually with Ctrl-F8 or Ctrl-F9, your monitor will blank) and connect the set-top box RF input to the VGA output using the cable you made.
- Configure your DVB-T set-top box to do a manual scan on channel 5 (178.75 MHz central frequency). After a few seconds, it should find a valid DVB-T signal (parameters: QAM 16, fft=2K, guard=1/32, conv=2/3). Two new channels should appear: *Lena Picture* and *Balears Picture*. Each one should display a nice still picture.
- You can also try the PAL (pal.pgm.gz) or SECAM (secam.pgm.gz) analog signals. You need to connect the VGA cable directly to your TV RF input and to use the `dac1` X11 mode instead of `dac2` (edit the X11 configuration file):

```
...
    SubSection "Display"
        Depth       8
        Modes        "dac1"
    EndSubSection
...
```

Then by tuning your TV on the VHF channel 5 (176.00 MHz image frequency) you should see a black and white Lena

picture.

How does it work ?

Every VGA card contains high speed [Digital to Analog Converters](#) (DACs), one for each Red, Blue and Green component. Here we use only the red DAC. The provided images have been computed so that the signal output to the DAC is a valid RF signal.

As we did not want to generate a 176 MHz signal directly, we use the fact that the VGA DACs generate a lot of harmonics. The real generated DVB-T signal has a central frequency of 25.71 MHz. Then the second harmonic has a frequency of $25.71 \times 2 = 51.42$ MHz which is almost exactly the central frequency of the VHF TV channel 5.

The DVB-T signal is generated with a DVB-T and DVB-H modulator I wrote from scratch. This is the most complicated step because the DVB-T modulation is quite complicated ([COFDM modulation](#)). A custom polyphase filter is used to interpolate the baseband COFDM complex signal. Then it is translated to the 25.71 MHz frequency.

I used a patched version of [FFmpeg](#) to generate a custom DVB Transport Stream containing two DVB services. Each one contains a still MPEG picture. One of the still picture is the very nice [Lena](#).

For PAL and SECAM, I also wrote a simple TV black and white PAL encoder. Adding color would be possible, but I am not motivated enough to do it :-)

Related links

- [Tempest for Eliza](#) is an AM radio modulator also using a VGA card. I got the idea of transmitting TV signals with a VGA card by looking at this project.
- The [GNU Radio project](#) contains source code for several modulators.

Interesting Ideas

- This project can be the basis of a real time low cost DVB-T and DVB-H modulator. Interested compagnies can contact me if they want to subsidize such a project. It can be very useful to test DVB-T set-top boxes, DVB-H cell phones and to test interactive broadcasted DVB-T or DVB-H applications.
- This project, coupled with the [GNU Radio project](#), can be the basis of many student projects to study digital communications. Compared to other solutions, it has the advantage of a very low cost (PCs are available everywhere). Students could write their own modulation code and immediately test the result with a DVB-T set-top box for example. Interested universities can contact me.
- With a very simple analog frequency translator, it could be possible to reach a better SNR (currently 14 dB is the maximum I could get in the VHF band) and higher frequencies.
- Color encoding could be added to the PAL/SECAM encoder and NTSC support.

Where is the source code ?

It is currently not available, although I plan to release it someday, provided enough people ask me to.

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